

Rabies Surveillance in California

Annual Report 2012

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Introduction

Rabies is a severe encephalitis caused by a Lyssavirus. Following a variable incubation period that can range from one week to several years, early clinical signs and symptoms of rabies, including headache, fever, chills, cough or sore throat, anorexia, nausea, vomiting and malaise, are non-specific and easily mistaken for more common conditions. Disease progresses rapidly (within 1-2 weeks) to central and peripheral neurologic manifestations including altered mental status (e.g., hyperactivity and agitation), irritation at the site where the virus was introduced, hydrophobia, hypersalivation and difficulty swallowing due to laryngeal spasms, and ultimately autonomic instability, coma, and death, mainly due to cardiac or respiratory failure. No treatment protocol has proven consistently effective for clinical rabies and nearly all cases are fatal. If a person is exposed to the virus, prompt post-exposure prophylaxis (PEP) by administration of rabies immune globulin and vaccine can prevent progression to clinical rabies.

Variants of rabies virus are maintained in certain mammalian species, but all viruses are capable of infecting any mammal, including humans. In California, bat variant viruses exist throughout the state, while skunk variants are found mostly north of the Tehachapi mountain range. Domestic animals (dogs, cats, and livestock) do not maintain independent transmission of rabies, but they can be infected through contact with rabid wildlife. Each year since 1957, the Director of the California Department of Public Health (CDPH) has identified counties in California where rabies constitutes a public health hazard. The Director has declared all 58 counties in California as rabies areas each year since 1987.

Since the early 20th century, CDPH has overseen the statewide rabies surveillance and control program. Local departments of public health and environmental health, animal control agencies and shelters, and medical and veterinary practitioners collaborate with CDPH to prevent rabies in California by:

- Providing reliable laboratory services for the diagnosis of rabies in humans and animals,
- Regulating and enforcing rabies vaccination of dogs to provide a protective “firewall” that reduces the potential for human exposure,
- Investigating reports of animals that bite humans,
- Assessing risk of rabies exposure by subjecting biting animals to isolation/observation or euthanasia/testing,
- Providing recommendations for PEP for exposed humans,
- Developing and disseminating preventive education on rabies, and
- Collecting, collating, and reporting surveillance data on rabies in humans and animals.

Reporting and Analysis

The California Code of Regulations (17 CCR §2500) lists rabies as a reportable disease. Health care providers, including physicians and veterinarians, in knowledge of a case or suspected case of rabies in a human or animal are required to report immediately to the local health officer. Infection with rabies is confirmed in animals by detection of rabies virus antigen, typically in central nervous system tissue, by direct fluorescent antibody assay (DFA), performed by a certified public health microbiologist. Diagnostic testing of suspected rabies in human patients is particularly challenging and no single test can accurately diagnose rabies ante-mortem, therefore several tests on multiple tissue samples are recommended. Diagnosis can be made by DFA (e.g., nuchal or brain biopsy), polymerase chain reaction (e.g., nuchal biopsy or saliva), or demonstration of rabies-specific antibodies in blood or cerebrospinal fluid by immunofluorescent antibody assay or Rapid Fluorescent Focus Inhibition Test (RFFIT). In 2012, 27 local public health laboratories in California had qualified microbiologists and resources to perform rabies testing in animals. The CDPH Viral and Rickettsial Diseases Laboratory (VRDL) provides primary and confirmatory testing for rabies in animals, diagnostic testing of suspect human rabies patients, and rabies virus variant typing. Local public health departments report confirmed cases of rabies in humans and animals to CDPH. This surveillance report summarizes information on human and animal rabies cases reported to CDPH in 2012.

Rabies in Animals

In 2012, specimens from 5903 animals were tested for rabies in California--a 13 percent decrease compared to the annual average for years 2003-2011 (6823). At least one animal was tested for rabies from 55 of 58 counties. Of those counties that tested animals for rabies, the number tested per county ranged from 2 to 626.

Rabies was confirmed in 252 animals, representing a 27 percent increase compared to the annual average for 2003-2011 (198). One or more rabid animals were identified in 43 counties (Table 1) which reported between 1 and 56 rabid animals per county.

Wild Animals

Rabies was diagnosed in 250 wild animals in 2012, accounting for 99 percent of all rabid animals reported to CDPH. Bats (227, 91%) were the most frequently reported wild animals, followed by skunks (16, 6.4%), foxes (6, 2.4%), and raccoons (1, 0.4%).

Bats

A total of 1771 bats from 55 counties were tested for rabies in 2012, a 14 percent increase from the annual average of 1560 bats tested in 2004-2011 (Figures A, B). The 227 rabid bats reported in 2012 represented a 44 percent increase from the annual average of 158 reported in 2003-2011 (Figure C). Twenty-one counties reported more rabid bats in 2012 than in 2011. The greatest number of rabid bats was reported in Los Angeles County (56)--a 56 percent increase compared to the 36 rabid bats reported in the county in 2011. The eight southernmost counties accounted for 56 percent of all

rabid bats detected in California in 2012. Rabid bats were most frequently reported during mid-summer and early autumn; nearly half of all rabid bats (108, 48%) were reported between Weeks 27 (July 1-7) and 39 (September 23-29; Figure D). Reports for only 11 rabid bats included information on species: 8 Mexican free-tailed bats (*Tadarida brasiliensis*), and 1 each little brown bat (*Myotis lucifucus*), pallid bat (*Antrozous pallidus*), and Western pipistrelle (*Pipistrellus hesperus*).

Skunks

A total of 372 skunks from 40 counties were tested for rabies in 2012, of which 16 were confirmed. The greatest numbers of rabid skunks were reported in El Dorado (5) and Monterey (5) counties. Rabid skunks were most frequently reported during summer months (Figure D); half of all rabid skunks (9, 56%) were reported between Weeks 23 (June 3-9) and 35 (August 26-1). None of the rabid skunks was identified to species.

Foxes

A total of 36 foxes from 16 counties were tested for rabies in 2012. Rabies was confirmed in six foxes from three northern counties: Trinity (3), El Dorado (2) and Siskiyou (1). Rabid foxes were most frequently reported during late autumn; half of all rabid foxes (3, 50%) were reported between Weeks 45 (November 4-10) and 51 (December 9-15).

Domestic Animals

In 2012, 3297 domestic animals (dogs, cats, horses, cattle, goats, sheep, and camelids) were tested for rabies. One rabid dog and one rabid cat were confirmed, comparable to the mean of 1.8 domestic animal rabies cases per year in 2002-2011.

In March 2012, a six-year-old dog from Monterey County developed jaw drop, excessive salivation, and progressive paresis. A local veterinarian euthanized the dog and submitted the brain to the Monterey County Public Health Laboratory for rabies testing. Atypical staining was observed in the brain and the specimen was forwarded to CDPH VRDL for evaluation. The VRDL reported the brain as positive for rabies virus by DFA and characterized the virus as consistent with California skunk variant. The dog was acquired as a stray in September 2011 and received one vaccine against rabies at that time. The owners reported no known or suspected contacts between the dog and wild animals, but allowed that the dog often ran unsupervised on their property. Two household members and two veterinary staff who had contact with the dog during the days in which it was potentially infectious received PEP. Two other vaccinated dogs in the household received rabies vaccine booster doses.

In April 2012, an unvaccinated domestic cat from Kern County was presented to a local veterinarian for evaluation after it developed unusual behavior, including biting two family members. The cat was euthanized and the brain submitted to the Kern County Public Health Laboratory for rabies testing. Rabies virus was detected by DFA; these results were subsequently confirmed at the VRDL. Strain typing performed by VRDL

identified that the rabies virus recovered from the cat aligned most closely with a Mexican free-tailed bat (*T. brasiliensis*) variant. Four household members and the veterinarian received rabies PEP.

Rabies in Humans

Rabies was diagnosed in one California resident in 2012 [U.S. Centers for Disease Control and Prevention 2012]. In late June 2012, a previously healthy 34-year-old male resident of Contra Costa County developed right arm and shoulder pain while traveling in Southeast Asia. In early July 2012, he was seen in two clinics in the Middle East with complaints of arm tremors and spasticity, anxiety, and malaise. He was hospitalized, developed progressive agitation, and became comatose. Three weeks later he was flown to a hospital in Europe where he subsequently died. Serum collected post-mortem was positive for antibodies to rabies virus by RFFIT. A rabies diagnosis was confirmed by DFA testing of brain tissue. The rabies virus was characterized as similar to a variant associated with the Mexican free-tailed bat (*T. brasiliensis*), a North American species common in the southern United States and Mexico.

Numerous potential animal exposures were investigated, but no suspicious activities were immediately apparent. Three weeks after initiating its investigation, Contra Costa County Health Services was contacted by an acquaintance of the case-patient who reported that in late March 2012 she had observed him touch a bat while in California. The acquaintance recalled that the patient pulled his hand back as if the bat had bitten him, but they did not discuss this event further nor did the patient seek medical assistance at that time. Subsequent investigation into this reported bat contact in September identified one other person who had contact with the bat; this individual received PEP.

During his potentially infectious period—defined as the approximately seven-week period from two weeks before onset of symptoms until death—the case-patient traveled on eight international flights through six countries. The U.S. Centers for Disease Control and Prevention coordinated efforts to identify and assess all potential contacts to the patient. Twenty-three persons who had contact with the case-patient received rabies PEP.

Rabies in the United States

A total of 6,162 cases of animal rabies and one case of human rabies were reported in the U.S. in 2012 [Dyer et al 2013]. Wild animals accounted for 91.6 percent of all cases; raccoons represented the largest proportion of cases (31.7%), followed by bats (27.3%) and skunks (25.0%). Domestic animals accounted for 8.4 percent of all rabid animals and included 84 dogs and 257 cats. California accounted for 4.2 percent of all animal cases and the only human case with onset in 2012.

Discussion

More rabid animals were identified in California in 2012 than in any year since 2002. This general increase was driven chiefly by bats; the 227 rabid bats detected in 2012 represent the greatest number of rabid bats in California for a given year since CDPH began tracking animal rabies in 1922. This increase reflected the combined effect of a 14 percent increase in the number of bats tested in 2012 and a nearly three percentage point increase in the proportion that tested positive, compared to the average for the preceding nine years (2003-2011). Rabid bats were frequently detected in Los Angeles County where the number of bats tested increased by nearly 50 percent compared to 2011 (308 vs. 222) and the proportion testing positive was 5.6 percentage points higher (18.2% vs. 12.6%) than the mean for the preceding eight years (2004-2011). The factors influencing the apparent dynamics of rabies virus in bat populations are unknown, but likely include both inherent (population size, age structure) and external (weather patterns) natural factors, as well as variations in surveillance practices.

Skunks remained the second most commonly identified rabid animal in California in 2012. Rabid skunks were identified in counties located within areas of the state historically recognized as enzootic for skunk rabies, including the San Joaquin/Sacramento Valleys, western Sierra Nevada foothills, and the central coast. In the last two decades, the number of rabid skunks reported each year has continued to decline: from more than 300-400 cases in the 1980s, to fewer than 100 cases in the early 2000s, to fewer than 20 cases in 2011 and 2012 (Figure F). It is unclear if this trend represents a true decrease in incidence or an artifact of reduced sampling; the number of skunks tested statewide decreased from an annual average of 602 in 2005-2009 to 370 in 2010-2012. Nevertheless, the proportion of skunks that tested positive also decreased in this period, from 5.8 percent in 2005-2009 to 4.6 percent in 2010-2012. Furthermore, this decline was not unique to the virus variant circulating in California skunks; nationwide, the number of skunks infected with specific skunk variant rabies virus decreased more than four-fold since the 1980s [Dyer et al 2013]. The factors driving the decrease in skunk rabies in North America remain unknown.

The six rabid foxes reported in 2012 represent a 27 percent decrease compared to the ten-year mean for 2002-2011. Rabies in California foxes during this ten-year span peaked in 2009 with an epizootic centered in Humboldt County (38 of 41 rabid foxes reported statewide that year). The rabid foxes reported in 2012 were not considered part of this epizootic, but likely represented normal spillover of skunk rabies into the native northern California fox population.

One case of rabies in a domestic dog was identified in 2012. This dog represented the first rabid dog in California since 2010 and only the fifth rabid dog in 2003-2012. Statewide mandatory vaccination and licensure laws, in force in California since the 1950s, have significantly reduced the incidence of rabies in domestic dogs. The rabid dog in 2012 was vaccinated against rabies approximately seven months prior to illness onset. However, as the dog was acquired as a stray without any prior medical history,

the rabies vaccine it received at that time could represent its first and only dose. Serum antibody titers stimulated by a single dose of rabies vaccine tend to peak within a few weeks then wane at a rate that varies by age, breed and size, type and brand of vaccine, and other, unknown factors [Kennedy et al 2007; Mansfield et al 2004; Minke et al 2009]. Long-term immunity is reliably conferred only following vaccine boosters administered at intervals specified in the vaccine label. A nationwide review [Murray et al 2009] of reported rabies cases from 1997 to 2001 revealed that nearly five percent of rabid dogs in the U.S. had a history of having received at least one dose of rabies vaccine. However, of 13 dogs for which vaccination status at the time of death was known, only two were considered currently vaccinated. ("Currently vaccinated" is defined as 30 - 365 days after primary immunization and 0 to 1095 days after subsequent boosters.) Of two cases of rabies in vaccinated dogs reported to the USDA Center for Veterinary Biologics between 2004 and 2007, one was not vaccinated strictly according to label recommendations and the other was vaccinated with a product subsequently determined to not meet minimum required potency [Frana et al. 2008]. There was no evidence to support competing hypotheses of reduced vaccine potency due to manufacturing errors, after-sale mishandling of vaccine (storage, reconstitution, administration), or blunted immune response due to an occult immunocompromising disease to explain the apparent vaccine failure in the rabid California dog in 2012.

The single cat diagnosed with rabies in California in 2012 was infected with a bat virus variant. Although the cat's owners did not recall any encounters with wildlife, a large colony of bats reported in a neighboring community may have increased opportunities for contact between bats and domestic pets. Cats are the domestic animals most frequently diagnosed with rabies in California and the United States. Nine rabid cats were identified in California between 2003 and 2012. Although some local ordinances require cats to be licensed and/or vaccinated, the absence of a statewide requirement leaves the majority of pet cats unprotected against rabies. Furthermore, unlike most dogs, many cats are not confined to their properties of residence and their expanded ranges increase opportunities for contact with wildlife. The natural predatory demeanor and curiosity of cats makes them more inclined to engage in close, repeated contact with potentially rabid wildlife, such as a downed bat. For these reasons, the American Association of Feline Practitioners Vaccination Advisory Panel recommends vaccination against rabies for all cats that live in rabies-endemic areas [Scherk et al 2013], which encompasses all of California.

The rabies fatality in the Contra Costa resident in 2012 was the sixth human rabies case identified in California since 2003 (Table 2). Three of these case-patients were infected while outside the U.S.—two with canine variants and one with a bat variant. A bat bite in California was known or strongly suspected as the route of infection for the 2012 case-patient (Mexican free-tailed bat) and a Trinity County resident in 2003 (silver-haired bat). The source of infection and circumstances of exposure could not be determined for the 2011 case-patient. A bat variant was identified for 17 of 31 human rabies cases diagnosed in the U.S. between 2003 and 2012; of these, eight were

Mexican free-tailed bat variant and four were silver-haired bat variant [Dyer et al. 2013]. Mexican free-tailed bats are common throughout the southwestern U.S. and found in all parts of California. Silver-haired bats are widespread in the western U.S.; in California they are most commonly found in the eastern Sierra and areas north of San Francisco/Sacramento [Greenhall and Frantz, 1994]. Persons who experience a known or suspected bite from any species of bat should seek immediate medical care and consultation regarding the need for rabies PEP.

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Table 1. Reported cases of rabies in animals, California, 2012.

COUNTY	BAT	SKUNK	CAT	DOG	COYOTE	FOX	HORSE	SHEEP	CATTLE	RACCOON	TOTAL
TOTAL	227	16	1	1	0	6	0	0	0	1	252
Alameda	3	0	0	0	0	0	0	0	0	0	3
-Berkeley City	1	0	0	0	0	0	0	0	0	0	1
Alpine	0	0	0	0	0	0	0	0	0	0	0
Amador	1	0	0	0	0	0	0	0	0	0	1
Butte	8	0	0	0	0	0	0	0	0	0	8
Calaveras	1	0	0	0	0	0	0	0	0	0	1
Colusa	1	0	0	0	0	0	0	0	0	0	1
Contra Costa	6	0	0	0	0	0	0	0	0	0	6
Del Norte	0	0	0	0	0	0	0	0	0	0	0
El Dorado	1	5	0	0	0	2	0	0	0	1	9
Fresno	3	0	0	0	0	0	0	0	0	0	3
Glenn	1	0	0	0	0	0	0	0	0	0	1
Humboldt	1	0	0	0	0	0	0	0	0	0	1
Imperial	0	0	0	0	0	0	0	0	0	0	0
Inyo	0	0	0	0	0	0	0	0	0	0	0
Kern	9	1	1	0	0	0	0	0	0	0	11
Kings	1	0	0	0	0	0	0	0	0	0	1
Lake	1	0	0	0	0	0	0	0	0	0	1
Lassen	0	0	0	0	0	0	0	0	0	0	0
Los Angeles	54	0	0	0	0	0	0	0	0	0	54
-Long Beach City	0	0	0	0	0	0	0	0	0	0	0
-Pasadena City	2	0	0	0	0	0	0	0	0	0	2
Madera	0	2	0	0	0	0	0	0	0	0	2
Marin	4	0	0	0	0	0	0	0	0	0	4
Mariposa	2	0	0	0	0	0	0	0	0	0	2
Mendocino	1	0	0	0	0	0	0	0	0	0	1
Merced	2	0	0	0	0	0	0	0	0	0	2
Modoc	0	0	0	0	0	0	0	0	0	0	0
Mono	0	0	0	0	0	0	0	0	0	0	0
Monterey	1	5	0	1	0	0	0	0	0	0	7
Napa	0	0	0	0	0	0	0	0	0	0	0
Nevada	2	0	0	0	0	0	0	0	0	0	2
Orange	14	0	0	0	0	0	0	0	0	0	14
Placer	6	0	0	0	0	0	0	0	0	0	6
Plumas	0	0	0	0	0	0	0	0	0	0	0
Riverside	17	0	0	0	0	0	0	0	0	0	17
Sacramento	3	3	0	0	0	0	0	0	0	0	6
San Benito	1	0	0	0	0	0	0	0	0	0	1
San Bernardino	10	0	0	0	0	0	0	0	0	0	10
San Diego	13	0	0	0	0	0	0	0	0	0	13
San Francisco	7	0	0	0	0	0	0	0	0	0	7
San Joaquin	0	0	0	0	0	0	0	0	0	0	0
San Luis Obispo	0	0	0	0	0	0	0	0	0	0	0
San Mateo	3	0	0	0	0	0	0	0	0	0	3
Santa Barbara	2	0	0	0	0	0	0	0	0	0	2
Santa Clara	3	0	0	0	0	0	0	0	0	0	3
Santa Cruz	1	0	0	0	0	0	0	0	0	0	1
Shasta	0	0	0	0	0	0	0	0	0	0	0
Sierra	0	0	0	0	0	0	0	0	0	0	0
Siskiyou	0	0	0	0	0	1	0	0	0	0	1
Solano	6	0	0	0	0	0	0	0	0	0	6
Sonoma	5	0	0	0	0	0	0	0	0	0	5
Stanislaus	0	0	0	0	0	0	0	0	0	0	0
Sutter	1	0	0	0	0	0	0	0	0	0	1
Tehama	0	0	0	0	0	0	0	0	0	0	0
Trinity	0	0	0	0	0	3	0	0	0	0	3
Tulare	2	0	0	0	0	0	0	0	0	0	2
Tuolumne	2	0	0	0	0	0	0	0	0	0	2
Ventura	15	0	0	0	0	0	0	0	0	0	15
Yolo	6	0	0	0	0	0	0	0	0	0	6
Yuba	4	0	0	0	0	0	0	0	0	0	4

Table 2. Reported cases of rabies in humans, California, 2003-2012.

Year	Age	Sex	County	Rabies virus variant
2003	66	Male	Trinity	Bat, Silver haired
2004	22	Male	Los Angeles*	Dog, El Salvador
2006	11	Male	San Joaquin*	Dog, Philippines
2008	16	Male	Santa Barbara*	Bat, Mexican free-tailed
2011	8	Female	Humboldt	Unknown
2012	34	Male	Contra Costa	Bat, Mexican free-tailed

*Imported cases; exposure occurred outside of California

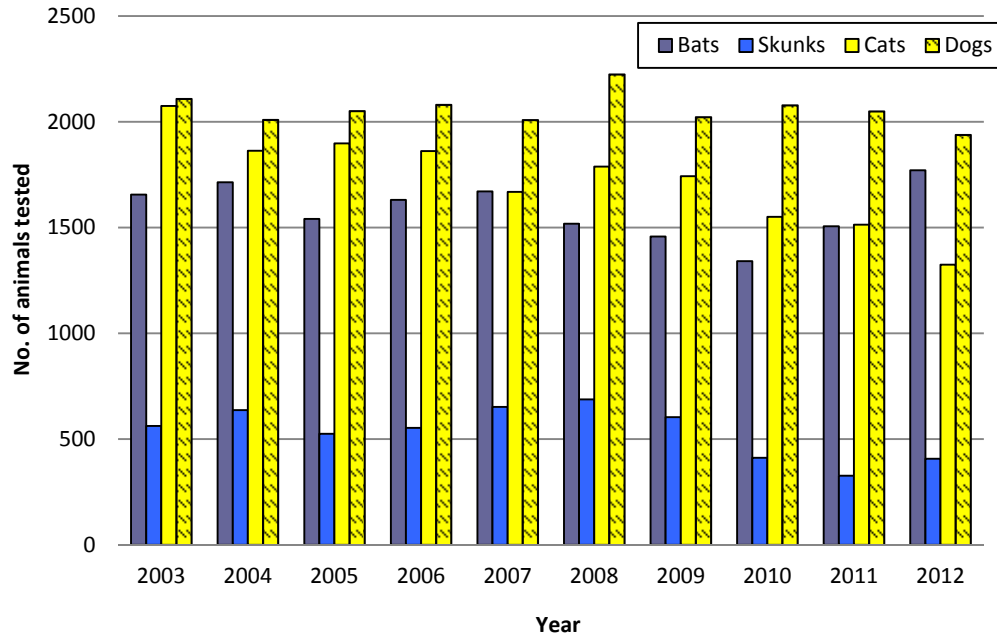


Figure A. Selected wild and domestic animals tested for rabies in California, 2003-2012.

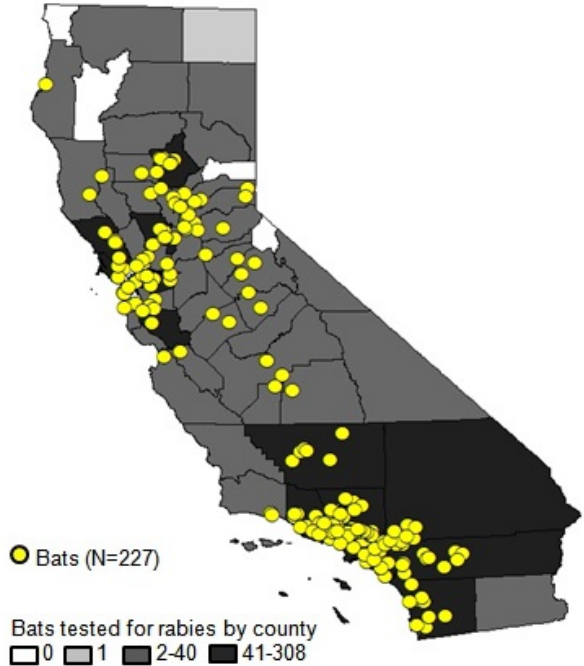


Figure B. Cases of rabies in bats by address of collection, California, 2012.

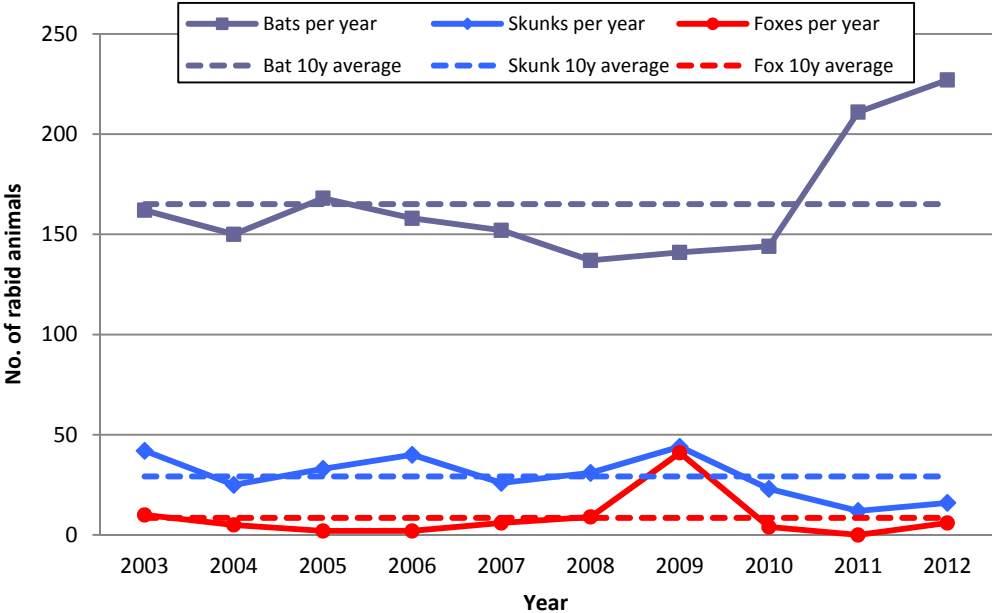


Figure C. Cases of rabies among wildlife in California, 2003-2012.

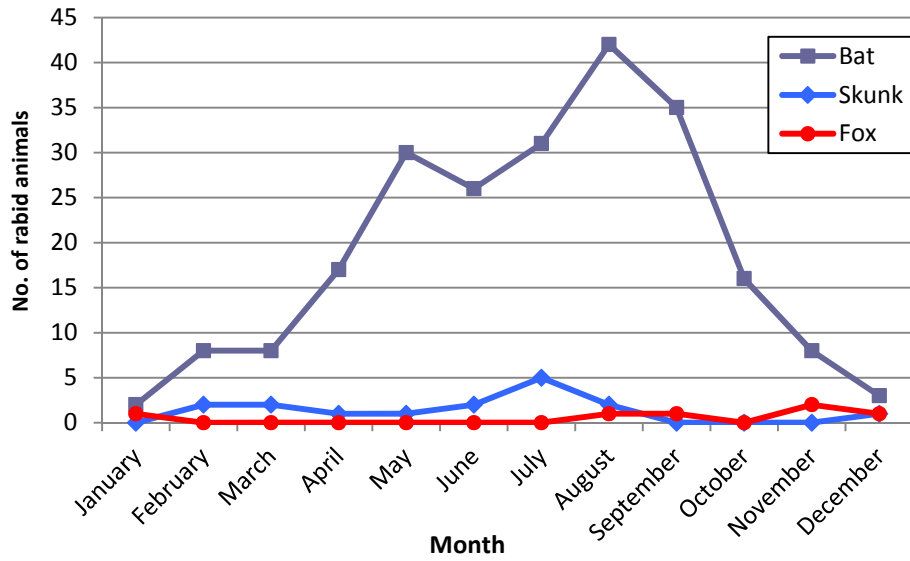


Figure D. Cases of rabies among wildlife by month of testing, California, 2012.

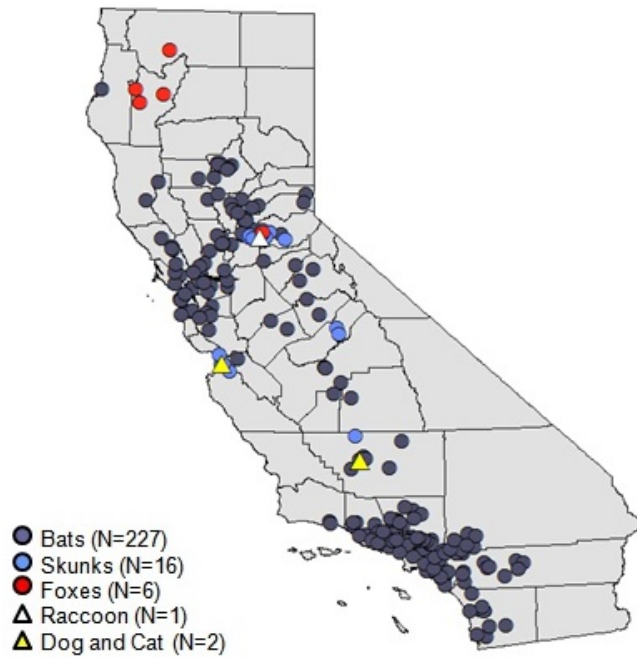


Figure E. Cases of rabies in wild and domestic animals by address of collection, California, 2012.

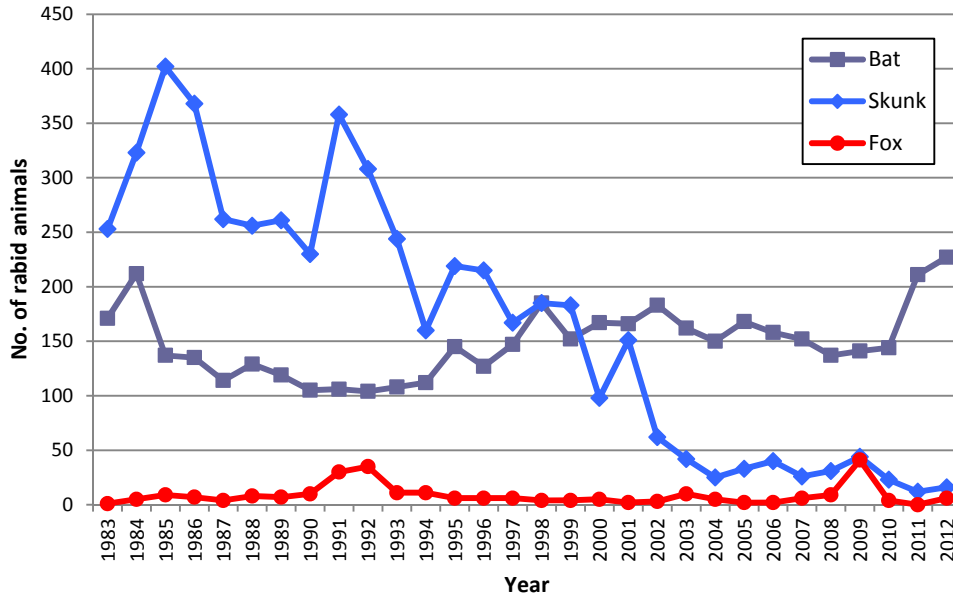


Figure F. Cases of rabies among wildlife in California, 1983-2012.